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IMMEDIATE STANDARDIZED LEARNING REINFORCEMENT TO A COMPLEX MENTAL-MOTOR SKILL (DRIVER TRAINING) USING ELECTRONICALLY-COORDINATED MOTION PICTURES.

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THE EDUCATIONAL EFFECTS OF A MULTISTATION, MOTION PICTURE, ELECTRONIC DRIVING SIMULATOR WERE STUDIED. THE SIMULATOR PROVIDED IMMEDIATE KNOWLEDGE OF RESULTS (FEEDBACK) USEFUL FOR ADJUSTING STUDENT DRIVING BEHAVIORS. THE STUDY INCLUDED 400 HIGH SCHOOL STUDENTS, RANDOMLY ASSIGNED TO EITHER AN EXPERIMENTAL OR A CONTROL GROUP. FOUR INSTRUCTORS TAUGHT 50 STUDENTS EACH IN THE EXPERIMENTAL GROUP AND IN THE CONTROL GROUP. EXPERIMENTAL SESSIONS WERE SUBDIVIDED INTO TWO APPROACHES--(1) NONINTEGRATED, IN WHICH ALL SIMULATED INSTRUCTION WAS COMPLETED BEFORE THE DUAL-CONTROL CAR LESSONS BEGAN, AND (2) INTEGRATED, IN WHICH THE SIMULATOR AND DUAL-CONTROL CAR LESSONS WERE INTERWOVEN. THE CONTROL SESSIONS OFFERED NO SIMULATOR TRAINING. PRECOURSE TESTS WERE USED TO ASSESS INTELLIGENCE, ATTITUDES, AND DRIVING KNOWLEDGE. THE DRIVING KNOWLEDGE AND ATTITUDE INSTRUMENTS WERE ADMINISTERED AGAIN AT COURSE END. INTEGRATED PROCEDURES WERE SIGNIFICANTLY BETTER FOR PREPARING STUDENTS FOR FINAL DUAL-CONTROL CAR TRAINING. THERE WERE NO SIGNIFICANT DIFFERENCES ON TESTS FOR STATE DRIVERS LICENSES OR ON FOLLOWUP TRAFFIC ACCIDENT OBSERVATIONS. ATTITUDES ESTABLISHED WITH THE INTEGRATED PROCEDURE WERE NOT SIGNIFICANTLY DIFFERENT FROM THOSE ESTABLISHED WITH NONINTEGRATED OR CONTROL PROCEDURES. FINDINGS WERE TABULATED AND PRESENTED WITH CONCLUSIONS AND IMPLICATIONS FOR EDUCATION AND RESEARCH. (WN)

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FINAL REPORT

"Immediate Standardized Learning Reinforcement to a Complex Mental-Motor Skill (Driver Training) Using Electronically-Coordinated Motion Pictures"

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SUMMARY

A need existed to determine the educational effect of a newly devised, multi-station, motion picture, electronic driving simulator which is the first driver trainer to provide immediate standardized feedback to students learning how to operate an automobile. More efficient and effective driving education is needed to meet rapidly expanding training and safety requirements.

The study involved 400 high school students who were assigned randomly to either Treatment A (experimental) or to Treatment B (control). A definition of these treatments in terms of instructional clock hours is as follows:

Instructional Areas	*Treatment A*	*Treatment B*
Classroom	27	30
Simulator	9	0
Behind-wheel of car	3	6
Car observation	3	6
Total	42	42

Each of the four instructors taught fifty students by Treatment A and another fifty students with Treatment B. Treatment A was subdivided into two parts to find the best way to use the simulator; two instructors used a non-integrated approach in which all simulated instruction was completed before the dual-control car lessons commenced while the other two instructors used an integrated approach so that the simulator lessons were interwoven with dual-control car training.

The pre-course instruments were the Lorge-Thorndike Intelligence Test, the Siebrecht Attitude Scale, the 1962 Knowledge Test of the American Automobile Association, and a locally-devised knowledge test. Both knowledge tests and the Siebrecht Attitude Scale were also administered at the end of the 1963–64 school year. A modified Amos Neyhart Road Skill Rating Scale for Passenger Car Drivers was completed by one of two independent judges during both the fourth and final twenty minute periods of behind-the-wheel of dual control car instruction.

The results indicate that the integrated simulator approach does a significantly better job of preparing students for their fourth and final periods of dual-control car training than does either the non-integrated simulator or the non-simulator methods. Overall there was no significant difference between treatments in passing the State Drivers License Skills Test. As of August 1, 1964 there were no significant differences in traffic accidents. It was indicated that nine hours of simulator time can be successfully substituted for three of six hours of behind-the-wheel instruction and three of six hours of observation in a dual-control car.

Students with a low error rate in the integrated simulator treatment were significantly better prepared for their fourth period of driving and somewhat better prepared for their final driving period and State License Examination than were students with a high error rate with the same method. The non-integrated simulator approach did not differentiate sufficiently between good and poor students.

On the basis of the final test using a locally devised knowledge examination, the non-simulator and the integrated simulator student means were significantly higher than that of the non-integrated simulator class. For the same test the integrated simulator group had the highest mean but this was not significantly higher than the mean of the non-simulator students. The integrated simulator group also had the highest means on both the 1962 American Automobile Association Knowledge Test and the Siebrecht Attitude Scale but these results were not statistically significant when compared with the means of the other two treatment groups.

The integrated simulator method produced significantly better results than did the non-simulator approach in the specific areas of driving skill of road position, turn-signals and intersections. In the specific areas of knowledge of stopping,

night speed, headlights, and passing, the integrated simulator approach resulted in significantly better results on the locally devised knowledge test than did either the non-integrated simulator or the non-simulator methods.

Girls in the integrated simulator treatment made fewer dual-control car errors and had less error variance than did girls taught by either the non-integrated simulator or the non-simulator methods. Girls have a significantly higher probability of passing the State Drivers License Skills Test the first time if they are trained with the integrated simulator approach rather than either the non-integrated simulator or the non-simulator methods.

Sex was the most important pre-experimental variable. The previous year's grade average had a low statistically significant correlation (—0.23) with fourth period car errors. The pre-knowledge local test and fourth period car errors correlated —0.28 while the pre-knowledge local test and final period car errors correlated —0.22. Intelligence, chronological age, attitude as measured by the Siebrecht Scale and knowledge as measured by the AAA test were not important in this experiment.

Major conclusions drawn from this particular study were:

1. Immediate standardized learning reinforcement involving instructional films which are coordinated electronically with individual learning stations in a simulator can be used to improve significantly the acquisition of complex mental-motor skills involved in learning to drive an automobile provided an integrated teaching approach is used where simulator instruction is interwoven with dual-control car instruction.

2. With an integrated teaching approach the new simulator with its immediate learning reinforcement can be used to substitute nine hours of simulated training for three of six hours of behind-the-wheel instruction and three of six hours of observation in a dual-control car.

3. With proper scheduling to take advantage of an improved student-teacher ratio in the simulator (12–1) compared to a dual-control car (2–1), the number of students trained per instructor per year can be increased 60 percent over the present conventional standardized programs provided conclusion 2 above is implemented.

4. Sex is probably the most and only really important pre-experimental difference in training high school students how to drive a car. On the average girls seem to start driver training at a lower skill level than do boys. The new simulator helps girls overcome this initial difference.

5. The new simulator with an integrated instruction method produces significantly better results than does the non-simulator method in the specific areas of driving skill of road position, turn-signals, and intersections.

6. The movie-simulator centered course does not appear to promote a significantly better attitude toward driving than does a dual-control car centered course.

7. With an integrated teaching approach the new simulator differentiates between good and poor students in learning to drive a car.

THE PROBLEM

An urgent need existed to determine the educational effect of a newly devised, multi-station, motion picture, electronic driving simulator which is the first driver trainer to provide immediate standardized feedback to students learning how to operate an automobile. More efficient and effective driving education is needed to meet rapidly expanding requirements. There has been a tremendous increase in the number of high schools offering Driver Education during the past two decades. For example, Pennsylvania had only three high schools offering Driver Education in 1943. Today, five hundred and eighty high schools in Pennsylvania provide Driver Education. Many other states have had similar expansions in this area. In order to cope with this expansion which

involves a tremendous backlog of students awaiting training, a shortage of qualified instructors, and the bulging requirements of the future, there is a need to find a more efficient way to teach students how to operate an automobile.

The new simulator holds promise of improved efficiency by increasing the number of students trained per instructor. The new driver trainer uses motion pictures which have been connected electronically with each of twelve simulated cars. This means a student-teacher ratio of 12 to 1 whereas a dual-control car normally provides a 2 to 1 student-teacher ratio. With well-timed scheduling the new simulator course should make it possible to train approximately sixty percent more students per instructor than by conventional means. This will lead to reduced costs per pupil trained. Zaun and Schroeder have reported that "In the Los Angeles City Schools, a 27 percent reduction in the per pupil cost of driver training . . . through the use of a drivo-trainer . . ."[1] The simulator tested here also seeks to improve the recognized ratio of simulator time to behind-the-wheel time.

In 1958, the National Conference on Driver Education convened under the leadership of the National Commission on Safety Education, National Education Association, and this conference set the presently recognized standard of four hours of simulated experience to each hour of actual practice driving instruction in an automobile. In this experiment three hours of simulator training was counted as the equivalent of one hour of behind-the-wheel instruction. This improved ratio, if successful, will save considerable time and money.

There was also a need to determine if the new simulator would provide more effective learning than the generally accepted course which involves thirty hours of classroom instruction, six hours of behind-the-wheel instruction, and six hours of car observation. In this experiment, there were twenty-seven hours of classroom instruction, three hours of behind-the-wheel instruction, three hours of car observation, and nine hours in the new simulator. The new simulator is the first driver trainer to provide immediate standardized feedback to students learning to operate an automobile.

In the new simulator if the student reacts incorrectly to the traffic situation depicted by the motion picture, a warning red light flashes on the student's private error identification panel. Then the student must correct the error in speed, or steering, or turn signals, or brakes, or head lights. The student knows that he is performing correctly when the red light is not flashing. Thus, students know immediately whether they are performing correctly or incorrectly.

It was desirable to find the application of stimulus-response learning theory where immediate standardized reinforcement is provided. In dual-control car instruction, the teacher variable is always present. In this new simulator-motion-picture instruction, there is a standardized programmed sequence from easy to difficult tasks provided by twelve movies where there is always immediate reinforcement of the same nature, time, and place. Allen[2] has reviewed film research and he has concluded that learner participation during a film and immediate knowledge of results facilitates learning. The Armed Forces have found an important relationship between improvement and immediate feedback of information concerning performance adequacy.[3] The Armed Forces also appreciate the fact that extremely dangerous conditions can be introduced in a simulator without risk to the learner or to others. During World War II the Link Trainer

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[1] Cecil G. Zaun and Melvin T. Schroeder, "Driver-Trainer: A Teaching Machine," Journal of Secondary Education, Vol. 37, No. 2, February 1962 pp. 112–16.

[2] William H. Allen, "Audio-Visual Communication," *Encyclopedia of Educational Research*, New York: The MacMillan Co., Third Edition, 1960 pp. 125–126.

[3] L. T. Alexander, C. H. Kepner, and B. B. Tregoe, "The Effectiveness of Knowledge of Results in a Military System-Training Program," *Journal of Applied Psychology*, Vol. 46, No. 3, June 1962, pp. 202–211.

which simulates blind flying by means of instruments became ". . . regulation equipment at every school where instrument flying was taught . . ."[4] Likewise, automatic driving simulators should be used to find new, more effective educational practice to decrease deaths, injuries, and their related tragedies.

Previous research[5] with other driving simulators has indicated that simulator-centered driving instruction is not superior to conventional practice driving in teaching desired skills and knowledge. In one experiment[6] it was indicated that the trainer group had a significant change in attitude while the control group did not. Prior studies[7] do indicate that sixteen hours in a driver trainer plus three hours of practice driving, and six hours of observation time results in as much learning as six hours of practice driving and twelve hours of observation. One recent study indicated that the simulator (used in this experiment) could be used satisfactorily for twelve hours plus three hours behind-the-wheel of a dual control car.[8]

In general, this project compared the results obtained with Treatment A (a driver course centered around motion pictures connected electronically with a simulator so as to provide immediate standardized feedback) with the results obtained with Treatment B (a driver course centered around behind-the-wheel instruction). Also nine hours in the simulator (rather than twelve hours) was substituted for three of the usual six hours of behind-the-wheel dual control car instruction. One half of the students in Treatment A were taught by an integrated approach and the other half were taught by an non-integrated approach.

Objectives

This experiment sought to determine the answers to these questions:

1. Will the driving skills of students taught by a motion-picture-simulator centered course (which provides immediate standardized feedback to students) differ significantly from the driving skills of students taught by a dual-control car centered course?
   a. Does the movie-simulator centered course better prepare students for the fourth period of practice driving than does the dual-control car centered course?
   b. Does the movie-simulator centered course better prepare students for the final period of practice driving than does the dual-control car centered course?
   c. Does the movie-simulator centered course better prepare students to pass the road skill part of a driver's license examination than does the dual-control car centered course?
   d. Do students trained by the movie-simulator centered course have significantly fewer traffic accidents during the first year of driving than do students trained by the dual-control car centered course?
   e. Can nine hours of simulator time be successfully substituted for three of six hours of behind-the-wheel instruction and three of six hours of observation in a dual-control car.
2. Are students with a low error rate on the simulator better prepared for their fourth and final practice driving periods and the driver's license examination and the first year of actual driving than students with a high error rate on the simulator?

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[4] *The Army Air Force in World War II*, W. F. Craven and J. C. Cate, Editors, Chicago: The University of Chicago Press, Vol. VI, 1955, p. 576.

[5] Herbert J. Stack, "A Resume and Evaluation of Research on the Training Effectiveness of Simulated Driving Experiences and Conventional Driver Education Methods," *Traffic Safety Research Review*, Vol. III, No. 4, December, 1959, pp. 12–14.

[6] *Ibid.*, p. 13.

[7] *Ibid.*, p. 14.

[8] Richard W. Bishop, "Evaluating Simulator Instruction for Accomplishing Driver Education Objectives," The Florida Institute for Continuing University Studies, Tallahassee, Florida.

3. Will driving knowledge of students taught by the movie-simulator centered course differ significantly from that of students taught by the dual-control car centered course?
4. Does the movie-simulator centered course promote a significantly better attitude toward driving safety than does a dual-control car centered course?
5. In which specific areas of skill, knowledge, and attitude does the movie-simulator centered course produce significantly different results than the dual-control car centered course?
6. Will there be a significant difference in results between boys taught by the movie-simulator centered course and girls taught in the same manner?

PROCEDURES

Subjects and Treatments

This study involved 400 high school students taking driver training during the 1963–64 school year. One half of the students were taught with Treatment A (experimental) and the other half with Treatment B (control).

A summary of hours is as follows:

Instructional Area	*Treatment A Hours**	*Treatment B Hours**
Classroom	27	30
Simulator	9	0
Behind-wheel-of-car	3	6
Car Observation	3	6
Total	42	42

* Note: Hours are defined as clock hours. Nine clock hours required twelve (45 minute) periods. Six clock hours required eight (45 minute) periods. Three clock hours required four (45 minute) periods.

Students were assigned randomly to Treatments A and B. The students were enrolled in the William Penn and the John Harris High Schools of Harrisburg, Pennsylvania. These are the two high schools of a city of approximately 100,000 people. One hundred John Harris students received Treatment A in the fall semester and one hundred John Harris students received Treatment B in the spring semester. One hundred William Penn students received Treatment B in the fall semester and one hundred William Penn students were taught by Treatment A in the spring semester.

An "integrated" approach was used in the Fall Semester at the John Harris High School. The integrated approach was one where the simulator instruction was interwoven with dual-control car instruction so that the students had four periods in the simulator and three periods in a dual-control car before the first rating by a judge using the Neyhart Rating Scale. In each period of dual-control car instruction each of two students received 20 minutes of practice driving and 20 minutes of observing another student being taught behind the wheel. The sequence of instruction was as follows: (Movies indicate simulator instruction)

Period	*Number of Minutes*	*Content*
1	45	"Introductory Film"
2	45	"Start of Good Driving"—(twice)
3	40	½ driving, ½ observation
4	40	½ driving, ½ observation
5	45	"The Good Turn"—(twice)
6	45	"City Driving" and "Highway Driving"
7	40	½ driving, ½ observation
8	40	½ driving, ½ observation
9	45	"Advanced City Driving"—(twice)
10	45	"Expressways" and "Shift for Yourself"
11	40	½ driving, ½ observation
12	40	½ driving, ½ observation
13	45	"Shift for Yourself" and "Parking"
14	45	"Driving After Dark"
15	40	½ driving, ½ observation
16	40	½ driving, ½ observation
17	45	"Let's Review"
18	40	½ driving, ½ observation

A "non-integrated" approach was employed in the Spring Semester at the William Penn High School. Here the students completed all of the simulator instruction prior to their first lesson in a dual-control car.

In all cases of simulator instruction (integrated or non-integrated) the following approach was employed. Each movie was introduced with approximately a four minute briefing to clarify objectives and to motivate students. Students were directed to raise their hand when in trouble so that individual help could be given. When either several hands were raised simultaneously or many red lights flashed in the same area at the same time, the movie was stopped so the difficulty could be clarified by the teacher and then the film was continued at an appropriate place. After each movie student questions were answered. Next there were questions asked by the teachers to emphasize the important points. The students were advised also of their errors by red light areas.

Control of Teacher Variable

There were two driving instructors at each high school. The instructors at one high school taught by Treatment A (experimental) in the fall semester while the instructors at the other high school taught by Treatment B (control). The reverse procedure was used in the spring semester so that each instructor taught by Treatment A (experimental) one semester and by Treatment B (control) the other semester. Each instructor had the same number of students each semester. It was then possible to compare the results each instructor obtained with a control group and an experimental group.

Pre-experimental Variables

The pre-course instruments were the Lorge-Thorndike Intelligence Test, the Siebrecht Attitude Scale, the 1962 Knowledge Test of the American Automobile Association, and a knowledge test (see Appendix A) devised by the involved instructors. Data were also collected for sex, age and prior year's grade average for each student.

Criterion Variables

Both knowledge tests (named above) and the Siebrecht Attitude Scale were administered at the end of the 1963–64 school year. Also a record of simulator errors was maintained for each simulator student for each movie. A Neyhart Road Skill Check List for Passenger Car Drivers was completed by one of two independent judges during both the fourth and final twenty minute periods of behind-the-wheel of a dual-control car. The Neyhart rating scale (see Appendix B) had been modified to delete items which did not pertain to either an automatic gear shift car or to the particular road course used in this experiment. Since the investigators wished to determine the reliability and validity of the modified Neyhart Scale and obtain an estimate of inter-judge reliability for the two involved judges, a brief experiment was conducted in April of 1963 and these results are summarized in Appendix C. Another criterion was the number of times each student needed to pass the State Operators License Examination. In addition, accident and traffic violations were analyzed.

Analysis of Data

Coefficients of correlations were computed to obtain insight into various relationships of IQ, attitude, knowledge, age, grade average, simulator errors, dual-control car driving errors, etc. Chi square was employed to compare simulator errors with dual-control car driving errors, and to compare simulator students versus non-simulator students in such areas as number of times required to pass the State Operators License Examination. Analysis of variance was used to compare the simulator and non-simulator students on attitude, knowledge, dual-control car driving errors, etc. Where analysis of variance indicated significant differences between means and the variance ratio test indicated that the standard deviations were significantly different, the Cochran and Cox Test was selected to compare means. Co-variance was used when the nature of the appropriate pre-experimental variables indicated that analysis of variance was inadequate for the comparison of the appropriate criterion variables.

RESULTS

Fourth Period Dual-Control Car Errors

Does the movie-simulator centered course better prepare students for the fourth period of practice driving than does the dual-control car centered course?

The results indicated that the integrated simulator approach better prepares students for the fourth twenty-minute period of practice driving in a dual-control car than do either the non-integrated simulator or the non-simulator methods.

Table 1
FOURTH PERIOD CAR DEDUCTIONS FOR THREE METHODS

Method	*N*	*Mean Errors*	*S.D.*
Non-Simulator	200	34.48	20.88
Integrated Simulator	100	25.93	14.47
Non-Integrated Simulator	100	37.03	20.97
Totals	400	32.98	19.95

Note: The variance for the integrated simulator approach is significantly smaller than the variance for the non-integrated simulator and for the non-simulator treatment. See pages 6 and 7 for definitions of treatments.

A significant difference exceeding the .001 level of confidence resulted between the means of the integrated simulator and non-simulator treatments ($t = 4.12048$ even when a significant difference in variances was adjusted by the Cochran and Cox t test). A significant difference exceeding the .001 level of confidence also resulted between the means of the integrated simulator and non-integrated simulator treatments ($t = 3.7934$ even when a significant difference in variances was adjusted by the Cochran and Cox t test). The difference between means was not significant ($t = 0.99431$) for the non-simulator treatment versus the non-integrated simulator treatment. These three comparisons indicate that the integrated simulator approach better prepares students for the fourth twenty-minute period of practice driving in a dual-control car than do either the non-simulator or the non-integrated simulator treatments.

Was there a significant difference in results at the William Penn High School for students taught by the non-integrated simulator method and those taught by the non-simulator approach? It should be noted that the following results are consistent with the above findings when all 200 non-simulator students were compared to 100 non-integrated simulator students.

Table 2
FOURTH PERIOD CAR RESULTS AT WILLIAM PENN

Method	*N*	*Mean Errors*	*S.D.*
Non-Integrated Simulator	100	37.03	20.97
Non-Simulator	100	31.74	17.63
Totals	200	34.38	19.55

The above differences in standard deviations result in an F variance ratio of 1.41479 which did not satisfy the 5% level of confidence for the F table value of 1.53. The above difference in means ($t = 1.93093$) did not satisfy the 5% table value of t of 1.99. It is indicated that at the William Penn High School the non-integrated simulator approach did not result in significant differences in either means or variance from the non-simulator treatment.

Was there a significant difference in results at the John Harris High School for the students taught by the integrated simulator approach and those taught by the non-simulator approach in respect to fourth period dual control car errors?

Table 3
FOURTH PERIOD CAR RESULTS AT JOHN HARRIS*

Method	*N*	*Mean Errors*	*S.D.*
Integrated Simulator	100	25.93	14.47
Non-Simulator	100	37.22	23.37
Totals	200	31.57	20.24

* These results are consistent with those shown in Table 1.

There was both a significant difference between means and between standard deviations for the above two groups. An F variance ratio test pro-

duced an F value of 2.60802 which exceeded the table F values of 1.59 at the 2% level of confidence and of 1.83 at the 1% level of confidence. The Cochran and Cox t Test resulted in a t of 4.96407 which exceeded the .001 level of confidence. It is indicated that at the John Harris High School the integrated simulator treatment resulted in significantly fewer errors and less variance by the fourth (twenty minute) period of behind-the-wheel of dual control car instruction than in the non-simulator treatment.

Final Period Dual-Control Car Errors

Does the movie-simulator centered course better prepare students for the final period of practice driving than does the dual-control car centered course? It should be noted that the final period of practice driving involved a much more difficult road course than did the fourth period. The results indicated that the integrated simulator treatment better prepares students for the final twenty-minute period of practice driving than do either the non-integrated simulator or the non-simulator treatments.

Table 4
FINAL PERIOD CAR DEDUCTIONS FOR THREE METHODS

Method	*N*	*Mean Errors*	*S.D.*
Non-Simulator	200	28.78	16.08
Integrated Simulator	100	23.66	11.45
Non-Integrated Simulator	100	30.26	13.80
Totals	400	27.87	14.65

A significant difference exceeding the .01 level of confidence resulted between the means of the integrated simulator and non-simulator treatments ($t = 3.16109$ even when a significant difference in variances was adjusted by the Cochran and Cox t Test). A significant difference exceeding the .001 level of confidence resulted between the means of the integrated simulator and the non-integrated simulator treatments ($t = 3.77541$ even when the Cochran and Cox t test was used to adjust for a not quite significant difference in variances). The difference between means is not significant ($t = 0.8277$) for the non-simulator treatment and the non-integrated simulator approach. These three comparisons indicate that the integrated simulator approach better prepares students for the final twenty-minute period of practice driving in a dual-control car than do either the non-integrated simulator or the non-simulator treatments.

Was there a significant difference in results at the William Penn High School for students taught by the integrated simulator approach and those taught by the non-simulator approach in respect to final period dual-control car errors?

Table 5
FINAL PERIOD CAR RESULTS AT WILLIAM PENN*

Method	*N*	*Mean Errors*	*S.D.*
Non-Integrated Simulator	100	30.26	13.80
Non-Simulator	100	28.22	16.05
Totals	200	29.29	14.91

* These results are consistent with results shown in Table 4.

The difference in variances is not significant since the F variance ratio value of 1.35267 did not satisfy the F table value of 1.39 at the 5% level of confidence. The difference in means also was not significant ($t = 0.96377$). It is indicated that by the final period in a dual-control car there were no significant differences in driving skill between students taught at the William Penn High School by either the non-integrated simulator or the non-simulator methods.

Was there a significant difference by the final car rating period at the John Harris High School in the driving skills of students taught by the integrated simulator and the non-simulator methods?

Table 6

FINAL CAR PERIOD ERRORS AT JOHN HARRIS*

Method	*N*	*Mean Errors*	*S.D.*
Integrated Simulator	100	23.66	11.45
Non-Simulator	100	29.33	15.91
Totals	200	26.50	14.15

* These results are consistent with results shown in Table 4.

The above difference in variances was significant at the 2% level of confidence (F variance ratio of 1.93076 exceeds the 1.59 table F value for 99 and 99 degrees of freedom).

The difference in means was significant at the 1% level of confidence ($t = 2.87817$ even when the Cochran and Cox t test was used to adjust the significant difference in variances). It is indicated that at the John Harris High School for the final car period there were significantly fewer driving errors and less variance for the students taught by the integrated simulator method than those taught by the non-simulator approach.

Road Skills Per Drivers License Exam

Does the movie-simulator centered course better prepare students to pass the road skill part of a State driver's license examination than does the dual-control car centered course? Generally the answer to this question is "No" based on this particular experiment. A chi square test based on the following table resulted in a value of 3.73936 which for four degrees of freedom did not satisfy the chi square table value of 9.488 at the 5% level of confidence.

Another result was that the integrated simulator treatment in this experiment was of considerable value in helping the female students pass the Driver's License Examination compared to the other two approaches.

Table 7

ACTUAL AND EXPECTED FREQUENCIES FOR DRIVERS LICENSE SKILLS TEST

	Number of Times to Pass Test						
	Once		*Twice*		*Three or More*		
Method	*A*	*E*	*A*	*E*	*A*	*E*	*Total*
Integrated Simulator	70	66.75	24	26.5	6	6.75	100
Non-Integrated Simulator	67	66.75	23	26.5	10	6.75	100
Non-Simulator	130	133.50	59	53.0	11	13.50	200
Totals	267		106		27		400

Note: In the above table, A equals Actual, and E equals Expected Frequency.

Table 8

Frequencies by Sex for Drivers License Skills Test for Integrated Simulator Approach

Sex	Percent Passing First Time	Number of Times to Pass: Once A	Once E	Twice A	Twice E	Total
Girls	72.2	39	37.8	15	16.2	54
Boys	67.4	31	32.2	15	13.8	46
Total		70		30		100

Note: 1. In the above table, A equals Actual and E equals Expected Frequencies.
2. The resulting chi square value was non-significant (0.26059). The girls did as well as the boys in this situation.

Table 9

Frequencies by Sex for Drivers License Skills Test for Non-Simulator Method

Sex	Percent Passing First Time	Number of Times to Pass: Once A	Once E	Twice A	Twice E	Total
Girls	52.5	64	79.30	58	42.7	122
Boys	84.6	66	50.70	12	27.3	78
Total		130		70		200

The chi square value for the above is 21.62602 which greatly exceeds table value of 6.635 for one degree of freedom at the 1% level of confidence. The boys did significantly better than the girls in the foregoing situation.

Table 10

Frequencies by Sex for Drivers License Skills Test for Non-Integrated Simulator Treatment

Sex	Percent Passing First Time	Number of Times to Pass: Once A	Once E	Twice A	Twice E	Total
Girls	55.3	26	31.49	21	17.39	47
Boys	77.4	41	35.51	12	19.61	53
Total		67		33		100

Chi square for the above is 5.50849 which exceeds the table value of 5.02 for one degree of freedom at the 2½% level of confidence. The boys did significantly better than the girls in the foregoing situation.

Based on the above three comparisons it is indicated that girls have a much better probability of passing the Drivers License Skills Test the first time if they are trained with the integrated simulator approach rather than the other two methods used in this experiment.

Coefficients of Correlation

The correlations between the variables in this experiment are contained in the following:

Table 11
Coefficients of Correlation

For All 400 Students)	
Fourth period car and final period car errors	+0.42*
Pre- and post-knowledge (locally devised test)	+0.60*
Pre- and post-knowledge (AAA test)	+0.47*
Pre- and post-attitude (Siebrecht scale)	+0.56*
IQ and fourth period car errors	−0.05
IQ and final period car errors	−0.10
IQ and post-knowledge (local test)	+0.48*
IQ and post-knowledge (AAA test)	+0.55*
IQ and post-attitude (Siebrecht scale)	+0.53*
Pre-attitude (Siebrecht) and fourth period car errors	−0.12
Pre-knowledge (AAA) and fourth period car errors	−0.12
Pre-knowledge (local test) and fourth period car errors	−0.28*
Post-attitude (Siebrecht) and final period car errors	−0.08
Post-knowledge (AAA) and final period car errors	−0.10
Post-knowledge (local test) and final period car errors	−0.22*
Sophomore grade average and fourth period car errors	−0.23*
Sophomore grade average and final period car errors	−0.04
Chronological age and fourth period car errors	+0.02
Chronological age and final period car errors	+0.09
(For 100 Integrated Simulator Students)	
Total simulator errors and fourth period car errors	+0.36*
First four simulator period errors and fourth period car errors	+0.32*
Total simulator errors and final period car errors	+0.10
Final period turn signal errors in simulator and in car	+0.19
Final period braking errors in simulator and in car	+0.24
Final period steering errors in simulator and in car	+0.01
Final period speed errors in simulator and in car	+0.10
(For 100 Non-integrated Simulator Students)	
Total simulator errors and fourth period car errors	+0.03
Total simulator errors and final period car errors	−0.01
Final period turn signal errors in simulator and in car	+0.24
Final period braking errors in simulator and in car	−0.08
Final period steering errors in simulator and in car	−0.05
Final period speed errors in simulator and in car	−0.02

* Indicates correlations significant at the 1% level of confidence.

Accidents During First Year of Driving

Do students trained by the movie-simulator centered course have significantly fewer traffic accidents during the first year of driving than do students trained by the dual-control car centered course? As of August 1, 1964 the records of the Bureau of Traffic Safety, Commonwealth of Pennsylvania, indicated that only one of the 100 first semester simulator students and only one of the 100 first semester non-simulator students had been involved in either an accident or a moving traffic violation.

Accordingly there was no significant difference in this experiment for the first six months of driving between students taught by the integrated simulator approach and those taught by the non-simulator method.

Improved Ratio of Simulator Time

Can nine hours of simulator time be successfully substituted for three of six hours of behind-the-wheel instruction in a dual-control car? The presently recognized standard is four hours of simulated experience for each hour of actual practice driving instruction in an automobile or a twelve hour simulator course substitutes presently for three of six hours of practice driving. An

improved ratio could save considerable time and money in driver education. The previously described results of this experiment indicate that with the integrated simulator approach the new simulator can improve the ratio of simulator time. It appears that nine hours of integrated simulation (with immediate learning reinforcement) can replace three hours of dual-control car instruction.

Ability of Simulator to Differentiate Between Good and Poor Students

Are students trained by the integrated simulator approach who have a low simulator error rate better prepared for their fourth and final periods of practice driving on their State License Test, than students with a high simulator error rate? It appears that the number of fourth period car errors were significantly lower for the students with a low simulator error rate compared to students with a high simulator error rate.

Table 12

INTEGRATED SIMULATOR ERRORS COMPARED TO FOURTH PERIOD DRIVING ERRORS

Students by Errors in Simulator	*Students by Fourth Period Car Errors*		
	Below Median	*Above Median*	*Totals*
Below Median	32	18	50
Above Median	18	32	50
Totals	50	50	100

From the above table a chi square of 7.84 was computed which for one degree of freedom exceeds the table value of 6.635 at the 1% level of confidence.

Table 13

INTEGRATED SIMULATOR ERRORS COMPARED TO FINAL PERIOD DRIVING ERRORS

Students by Errors in Simulator	*Students by Final Period Car Errors*		
	Below Median	*Above Median*	*Totals*
Below Median	29	21	50
Above Median	21	29	50
Totals	50	50	100

From the above table a chi square of 2.56 was computed which for one degree of freedom does not satisfy the table value of 3.841 at the 5% level of confidence but it does satisfy the table value of 2.493 at the 12% level of confidence.

Are students trained by the integrated simulator approach who have a low simulator error rate better prepared to pass the State Driver License Skills Test than the students who have a high simulator error rate?

Table 14

INTEGRATED SIMULATOR ERRORS COMPARED TO ABILITY TO PASS DRIVERS LICENSE SKILLS TEST

Students by Errors in Simulator	*Number of Times to Pass License Skills Test*		
	Once	*Twice or More*	*Totals*
Below Median	39	11	50
Above Median	31	19	50
Totals	70	30	100

From the above table a chi square of 3.04762 was computed which does not satisfy the table value of 3.841 at the 5% level of confidence but it does satisfy the table value of 2.933 at the 9% level of confidence. The three foregoing comparisons indicate that with the integrated simulator approach the simulator does differentiate between good and poor students; this is particularly true with reference to fourth period practice driving errors.

Are students trained by the non-integrated simulator approach who have a low simulator error rate better prepared for their fouth and final periods of practice driving and their State License Test than students with a high simulator error rate? Again the non-integrated simulator approach does not appear to be the best way to use the simulator.

Table 15

NON-INTEGRATED SIMULATOR ERRORS COMPARED TO FOURTH PERIOD DRIVING ERRORS

Students by Errors in Simulator	*Students by Fourth Period Car Errors*		
	Below Median	*Above Median*	*Totals*
Below Median	26	24	50
Above Median	24	26	50
Totals	50	50	100

Table 16

NON-INTEGRATED SIMULATOR ERRORS COMPARED TO FINAL PERIOD DRIVING ERRORS

Students by Errors in Simulator	*Students by Final Period Car Errors*		
	Below Median	*Above Median*	*Totals*
Below Median	28	22	50
Above Median	22	28	50
Total	50	50	100

Table 17

NON-INTEGRATED SIMULATOR ERRORS COMPARED TO ABILITY TO PASS DRIVERS LICENSE SKILLS TEST

Students by Errors in Simulator	*Number of Times to Pass License Skills Test*		
	Once	*Twice or More*	*Totals*
Below Median	31	19	50
Above Median	36	14	50
Totals	67	33	100

The above three tables were used to compute non-significant chi square values of 0.16, 1.44, and 1.13068 respectively. The non-integrated simulator approach did not differentiate between good and poor students based on the above comparisons.

Driving Knowledge Results Per Local Test

Will driving knowledge of students taught by the movie simulator centered course differ significantly from that of students taught by the dual-control car centered course? Results in this area were analyzed first for a fifty item knowledge test (see Appendix A) devised locally by the instructors involved in this experiment.

Analysis of covariance was selected since (1) a coefficient of correlation of +0.48 (significant at the 1% level of confidence for 400 students) was obtained between IQ and the post-test results for the locally devised knowledge test, and (2) the difference between IQ means closely approached the 5% level of confidence. Also a significant correlation of +0.60 was obtained between pre- and post-knowledge test results as well as a significant difference at the 5% level of confidence resulted between the pre-test knowledge means of the three different treatments.

Table 18

MEANS AND STANDARD DEVIATIONS OF THE CRITERION (LOCAL KNOWLEDGE TEST RESULTS) AND CONTROL VARIABLES

Method	*No.*	*Post-test Knowledge*		*IQ*		*Pre-test Knowledge*	
	K	*M*	*S.D.*	*M*	*S.D.*	*M*	*S.D.*
Integrated Simulator	100	39.99	3.79	106.42	14.81	32.90	5.12
Non-Integrated Simulator	100	36.89	4.35	101.45	14.03	31.33	5.33
Non-Simulator	200	38.58	3.27	103.68	13.81	31.81	4.03
Totals	400	38.51	3.86	103.81	14.18	31.96	4.7

Table 19

ANALYSIS OF COVARIANCE FOR FINAL RESULTS FOR LOCAL KNOWLEDGE CORRECTING FOR IQ AND PRE-TEST KNOWLEDGE

Source of Variation	*Residuals*		
	Degrees of Freedom	*Sum of Squares*	*Mean Square*
Total	397	3101.15747	
Within	395	2901.47085	7.34549
Difference	2	199.68662	99.84331

Covariance resulted in an F ratio of 13.59246 which exceeds the table value of 4.66 for 2 and 395 degrees of freedom at the one percent level of confidence. The following table indicates which adjusted means contributed to this significant difference (results computed by Cochran and Cox t test):

Table 20

DIFFERENCES BETWEEN ADJUSTED MEANS FOR LOCAL KNOWLEDGE POST-TEST

Methods	*Means*	*M-C*	*M-B*
A — Integrated Simulator	39.35	A − C = 1.98*	A − B = 0.63 n.s.
B — Non-Simulator	38.72	B − C = 1.35**	
C — Non-Integrated Simulator	37.37		

* The difference between the means of the integrated and the non-integrated simulator methods was significant at the .001 level of confidence (t = 4.44056) in favor of the integrated simulator approach.

** The difference between means of the non-simulator and the non-integrated simulator methods was significant at the .01 level of confidence (t = 2.7282) in favor of the non-simulator approach.

n.s. — The difference between means of the integrated and non-simulator methods was not significant (t = 1.4129).

Driving Knowledge Results Per AAA Test

Will driving knowledge of students taught by the movie simulator centered course differ significantly from that of students taught by the dual-control car centered course? Previously this area was analyzed for the results on a fifty item knowledge test (see Appendix A) devised locally by the instructors involved in this experiment. This area was also analyzed for the results on a twenty-five item 1962 Knowledge Test of the American Automobile Association.

Analysis of covariance was selected for the results on this AAA Knowledge Test since (1) a coefficient of correlation of +0.55 (significant at the 1% level of confidence for 400 students) was obtained between IQ and the post-results on the AAA Test, and (2) the difference between IQ means closely approached the 5% level of confidence. Covariance was also selected since (1) a coefficient of correlation of +.47 (significant at the 1% level of confidence) was obtained between pre- and post-results for the AAA Test, and (2) a significant difference was obtained at the 1% level of confidence for the pre-test means.

Table 21

MEANS AND STANDARD DEVIATIONS FOR THE CRITERION (AAA KNOWLEDGE POST-TEST) AND CONTROL VARIABLES

Method	*No.*	*Post-test Knowledge*		*IQ*		*Pre-test Knowledge*	
	K	*M*	*SD*	*M*	*SD*	*M*	*SD*
Integrated Simulator	100	13.99	3.14	106.42	14.81	10.37	2.80
Non-integrated Simulator	100	12.31	2.73	101.45	14.03	8.51	2.98
Non-simulator	200	12.84	2.97	103.68	13.81	8.80	3.13
Totals	400	13.00	3.10	103.81	14.81	9.12	3.02

Table 22

ANALYSIS OF COVARIANCE FOR FINAL RESULTS KNOWLEDGE TEST CORRECTING FOR IQ AND PRE-TEST KNOWLEDGE

Source of Variation	*Residuals*		
	Degrees of Freedom	*Sum of Squares*	*Mean Square*
Total	397	2288.19507	
Within	395	2260.48907	5.72275
Difference	2	27.70600	13.8530

Covariance resulted in an F ratio of 2.42068 which did not satisfy the table value of 3.02 for 2 and 395 degrees of freedom at the five percent level of confidence. A significant difference was not obtained between the means of the three treatment groups for the end of the year results with the AAA Knowledge Test.

Attitudinal Results

Does the movie-simulator centered course promote a significantly better attitude toward driving safety than does a dual-control car centered course? The forty item Siebrecht Attitude Test was used with local modifications for simplified scoring. The scoring was dichotomized so that a correct answer was scored as one and incorrect answer as zero. Answers of either "Strongly Agree" or "Agree" were counted the same since words mean different things to different people and "Strongly Agree" means to some what "Agree" means to others. Likewise a response of "Disagree" or "Strongly Disagree" were counted the same. In view of the preceding decisions, items 1, 9, 22, and 31 were not counted at all since "Undecided" is the coded response.

Analysis of covariance was selected since (1) a coefficient of correlation of +0.53 (significant at the 1% level of confidence for 400 students) was obtained between IQ and the attitudinal post-test results; and (2) the difference between IQ means closely approached the 5% level of confidence. Also it was noted that (1) significant coefficient of correlation of +0.56 resulted between pre- and post-attitudinal scores, and (2) a significant difference between pre-test attitudinal means was obtained at the 1% level of confidence.

Table 23

MEANS AND STANDARD DEVIATIONS OF THE CRITERION (END OF YEAR ATTITUDE) AND CONTROL VARIABLES

	No.	Post-Test Attitude		IQ		Pre-Test Attitude	
Method	K	M	SD	M	SD	M	SD
Integrated Simulator	100	30.75	4.27	106.42	14.81	27.64	4.65
Non-integrated Simulator	100	28.69	4.32	101.45	14.03	25.14	5.98
Non-simulator	200	29.44	5.22	103.68	13.81	26.60	5.81
Totals	400	29.55	4.83	103.81	14.81	26.50	5.66

Table 24

ANALYSIS OF COVARIANCE FOR END OF YEAR ATTITUDE CORRECTING FOR IQ AND PRE-TEST ATTITUDE

	Residuals		
Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Total	397	5702.03237	
Within	395	5667.49484	14.34808
Difference	2	34.53753	17.26877

Covariance resulted in an F ratio of 1.20355 which did not satisfy the table value of 3.02 for 2 and 395 degrees of freedom at the five percent level of confidence. A significant difference was not obtained between the means of the three treatment groups for the end of the year results for the Siebrecht Attitude Scale.

Specific Areas of Skill

In which specific areas of skill did significantly different results occur? The number of deductions in the fourth period of practice driving (raters used the Neyhart Scale—See Appendix B) were as follows:

Table 25

SPECIFIC SKILL AREAS—PUPIL ERRORS IN FOURTH PERIOD OF DRIVING

		Deductions By Treatments[a]		
Item Number	Specific Area[a]	Integrated Simulator	Non-integrated Simulator	Non-Simulator
1	Pre-start	78[a]	131	96
2	Starting	48	57	64
3, 4	Steering	111[b]	135[b]	208
5	Road Position	73[a,b]	130	136
6, 9[a], 11[b], 12[b]	Speed	479[a,b]	667	644
7	Turn-signals	42[b]	52	71
8, 9, 10, 11, 12, 13	Intersections	1 277[a,b]	1 944[a]	1 556
14	Smoothness of Operation	125[a,b]	440	438
15	Passing	—	—	3
16[c]	Rear View Mirror	321	309	301
2[c], 6[d], 10[a], 13[b], 13[c], 14[a]	Braking	598[b]	549[b]	788

[a] One-half of the non-simulator errors are entered here to make the data comparable since there were 200 non-simulator students compared to 100 students per each of the other two treatments. Each of two judges rated half of the students in each group.

[a] Chi-square was used to compare results.

[a] Significantly fewer errors at the 1% level of confidence than the number of non-integrated simulator student errors.

[b] Significantly fewer errors at the 1% level of confidence than the number of non-simulator student errors.

[c] Significantly more deductions at the 1% level of confidence than the number of non-simulator student errors.

Only one of the above differences (intersections) favored the non-simulator treatment over the non-integrated simulator method. In two cases (steering and braking) the non-integrated simulator method was significantly better than the non-simulator method. In seven specific areas (steering, road position, speed, turn-signals, intersections, smoothness of operation, and braking) the integrated simulator method resulted in significantly fewer errors than did the non-simulator treatment.

The number of skill deductions in the final period of practice driving (over a more difficult course than during the fourth period) were as follows:

Table 26

SPECIFIC SKILL AREAS—PUPIL ERRORS IN FINAL PERIOD OF DRIVING

Item Number	*Specific Area*[a]	*Deductions By Treatments*[g]		
		Integrated Simulator	*Non-integrated Simulator*	*Non-Simulator*
1	Pre-start	42	37	59
2	Starting	18	26	26
3, 4	Steering	94	86	86
5	Road position	182[a,b]	245	248
6, 9[e], 11[b], 12[b]	Speed	724[a]	869	811
7	Turn-signals	100[a,b]	180	144
8, 9, 10, 11, 12, 13	Intersections	863[a,b]	1 274	1 143[c]
14	Smoothness of Operation	155[a]	225	183
15	Passing	0	20	15
16[f]	Rear View Mirror	299	297	307
2[e], 6[d], 10[e], 13[b], 13[c], 14[e]	Braking	225[a]	307	255

[g] One-half of the non-simulator errors are entered here to make the data comparable since there were 200 non-simulator students compared to 100 students per each of the other two treatments. Each of two judges rated half of each group.

[a] Chi-square was used to compare results.

[e] Significantly fewer errors at the 1% level of confidence than the number of non-integrated simulator student errors.

[b] Significantly fewer errors at the 1% level of confidence than the number of non-simulator student errors.

[c] Significantly fewer errors at the 1% level of confidence for the non-simulator students compared to the non-integrated simulator students.

For the final period of practice driving in all eleven specific skill areas, the integrated simulator students had fewer deductions than did the non-simulator students. In three skill areas (road position, turn-signals, and intersections) the integrated simulator group committed significantly fewer errors (at the 1% level of confidence) than did the non-simulator group. There was one area (intersections) where the non-simulator students had significantly fewer errors than the non-integrated simulator students. There were six skill areas (road position, speed, turn-signals, intersections, smoothness of operation, and braking) where the integrated simulator treatment resulted in significantly fewer errors (at the 1% level of confidence) than did the non-integrated simulator treatment.

Specific Areas of Knowledge

In which specific areas of knowledge did significantly different results occur for the final test using the locally-devised knowledge test (See Appendix A)?

Table 27

Specific Knowledge Areas in Which Significant Differences Occurred on Locally-Devised Knowledge Test

Item Number	Specific Area[a]	Percent Right Answers By Treatment[a]		
		Integrated Simulator	Non-integrated Simulator	Non-Simulator
3	Stopping[c]	86.60	70.97	73.66
5	Night Speed[b]	76.29	50.00	59.68
7	Headlights[b]	91.75	70.97	73.66
8	Left Turns[c]	91.75	77.47	84.41
14	Passing[c]	74.23	46.77	59.14
16	School Bus[d]	80.41	51.61	69.89
23	Traffic Signs[e]	44.33	64.52	54.84
24	Speed[d,f]	62.89	45.16	68.28
32	Backing[f]	49.48	35.48	58.06

[a] Percents shown to make above data comparable since there were 200 non-simulator students compared to 100 students per each of the other two treatments.

[b] Chi-square was used to analyze results using actual frequencies.

[c] Number of right answers was significantly different (at the 5% level of confidence) in favor of the integrated simulator method versus each of the other two treatments.

[b] Number of right answers was significantly different (at the 1% level of confidence) in favor of the integrated simulator method versus each of the other two treatments.

[c] Number of right answers was significantly different (at the 5% level of confidence) in favor of the integrated simulator method versus the non-integrated simulator method.

[d] Number of right answers was significantly different (at the 1% level of confidence) in favor of the integrated simulator method versus the non-integrated simulator method.

[e] Number of right answers was significantly different (at the 5% level of confidence) in favor of the non-integrated simulator method versus the integrated simulator method.

[f] Number of right answers was significantly different (at the 1% level of confidence) in favor of the non-simulator versus the non-integrated simulator method.

On the final test of knowledge for the locally-devised test significant differences in favor of the integrated simulator method over each of the other two treatments were obtained in four specific areas (stopping, night speed, headlights, and passing). Also the integrated simulator method was significantly better than the non-integrated simulator method in these three additional areas: left turns, school bus (when stopped), and speed (danger zones). In two areas (speed and backing) the non-simulator treatment was significantly better than the non-integrated simulator approach. There were no areas in which the non-simulator group was significantly better than the integrated simulator approach while the latter group was significantly better than the former in four specific areas (stopping, night speed, headlights, and passing).

In which specific areas of knowledge did significantly different results occur with Form C, 1962 Knowledge Test of the American Automobile Association at the end of the school year?

Table 28

Specific Areas in Which Significant Differences Occurred on AAA Knowledge Test

Item Number	Specific Area[a]	Percent Right Answers By Treatment[a]		
		Integrated Simulator	Non-integrated Simulator	Non-Simulator
8	Traffic signs[c]	61.00	40.32	55.49
9	Grade Separation[b,c]	40.00	17.74	27.47

[a] Percents shown to make above data comparable since there were 200 non-simulator students compared to 100 students per each of the other two treatments.

[b] Chi square was used to analyze results using actual frequencies.

[c] The number of right answers for the non-integrated simulator group was significantly smaller (at the 5% level of confidence) than for the other two groups.

[b] The number of right answers for the integrated simulator group was significantly greater than the non-integrated simulator group at the 1% level of confidence.

[c] The number of right answers for the integrated simulator group was significantly greater than the non-simulator group at the 5% level of confidence.

Specific Areas of Attitude

In which specific areas of attitude did significantly different results occur with the Siebrecht Attitude Scale at the end of the school year?

Table 29

Specific Areas in Which Significant Differences Occurred on the Siebrecht Attitude Scale

Item Number	Specific Area[a]	Percent Right Answers By Treatment[a]		
		Integrated Simulator	Non-integrated Simulator	Non-Simulator
23	Law Enforcement[c]	93.75	79.63	86.79
26	Traffic Lights[b]	90.63	79.63	91.38

[a] Percents shown to make above data comparable since there were 200 non-simulator students compared to 100 students in each of the other two treatments.

[b] Chi square was used to analyze results using actual frequencies.

[c] The number of positive answers for the integrated simulator group was significantly greater (at the 1% level of confidence) than for the non-integrated simulator group.

[b] The number of positive answers for the non-simulator group was significantly greater (at the 5% level of confidence) than for the non-integrated simulator approach.

Differences According to Sex

It was previously reported on page 12 that girls had a much easier time passing the State Operators License Skills Test on the first occasion if they were trained with the integrated simulator approach rather than the other two methods used in this experiment.

Was there a significant difference in results between girls and boys (taught by three methods) in fourth period car errors?

Table 30

FOURTH PERIOD CAR ERRORS BY METHOD AND SEX

Method	Girls			Boys			t-value
	No.	Mean	S.D.	No.	Mean	S.D.	
Integrated Simulator	54	25.67	12.82	46	26.35	16.19	0.22760
Non-integrated Simulator	47	40.83	23.19	53	33.66	18.12	1.68976
Non-Simulator	122	38.66	23.15	78	27.95	14.49	4.00364
Totals	223	35.95	22.01	177	29.24	16.26	

The above t-values were computed by the Cochran and Cox procedure to equate unequal standard deviations. It can be seen that the girls taught by the integrated simulator approach did as well as the boys taught by the same method. The girls in the non-integrated simulator treatment committed more errors than did the boys taught the same way but the difference in means (7.17) resulted in a t-value of 1.68976 which was not significant at the 5% level of confidence (the calculated table value of t = 2.01254). The girls in the non-simulator treatment committed significantly more errors than did the boys taught the same way since the difference in means (10.71) resulted in a t-value of 4.00364 which exceeded the calculated table value of t of 2.62881 at the 1% level of confidence.

It should be noted that the integrated simulator girls achieved the least error variance for all six groups represented in Table 30. The girls taught by the non-integrated and non-simulator methods had significantly greater error variance (exceeding the 5% level of confidence) than did the boys who were taught by the same methods. Also the error variance was significantly smaller (at the 1% level of confidence) for the girls taught by the integrated simulator approach compared to the girls taught by the other two methods. In addition, the error variance of the integrated simulator girls was smaller than for the boys taught in the same way although the F-variance ratio of 1.59484 did not satisfy the F-table value of 1.603 at the 5% level of confidence.

Was there a significant difference in results between girls and boys (taught by three methods) in final period car errors?

Table 31

FINAL PERIOD CAR ERRORS BY METHOD AND SEX

Method	Girls			Boys			t-value
	No.	Mean	S.D.	No.	Mean	S.D.	
Integrated Simulator	54	26.15	11.68	46	20.74	10.42	2.44732*
Non-integrated Simulator	47	33.57	14.42	53	27.32	12.52	2.27690*
Non-simulator	122	30.48	16.48	78	26.10	14.81	1.94085 n.s.
Totals	223	30.08	15.22	177	25.07	13.37	

Table 31 (continued)

Source of Variation	Analysis of Variance			
	Degrees of Freedom	Sum of Squares	Mean Squares	F-Values
Sex	1	2478.55113	2478.55113	12.90052[a]
Method	2	2507.4225	1253.71125	6.52539[b]
Interaction	2	5121.60488	2560.80244	13.32863[a]
Within	394	75698.39899	192.12791	
Total	399	85805.9775		

[a] Significant at the 2% level of confidence.

[b] Significant at the 5% level of confidence.

n.s. Not significant.

[a] Significant at the 1% level of confidence.

It is indicated that sex as well as method make a significant difference in learning to drive a car.

Table 32
FINAL DRIVING KNOWLEDGE ON LOCAL TEST BY METHOD AND SEX

Method	Girls			Boys			t-value
	No.	Mean	S.D.	No.	Mean	S.D.	
Integrated Simulator	54	39.96	3.39	46	40.02	4.21	0.07758
Non-integrated Simulator	47	36.43	4.21	53	37.30	4.58	0.98960
Non-simulator	122	37.70	1.48	78	39.94	5.10	3.41140
Totals	223	37.98	3.04	177	39.17	4.65	

The nature of the pertinent pre-experimental variables did not require covariance analysis. The difference of 0.06 between the means of the girls and boys in the integrated simulator treatment was not significant. Likewise the difference of 0.87 between the means of the girls and boys in the non-integrated simulator approach was not significant. The difference of 2.24 between the means of the girls and boys in the non-simulator treatment resulted in a Cochran and Cox t-value of 3.41140 which was significant at the 1% level of confidence.

Was there a significant difference in results between girls and boys (taught by three methods) in final driving knowledge as measured by the 1962 American Automobile Test (Form C)?

Table 33
FINAL DRIVING KNOWLEDGE ON AAA TEST BY METHOD AND SEX

Method	Girls			Boys			t-value
	No.	Mean	S.D.	No.	Mean	S.D.	
Integrated Simulator	54	14.31	3.21	46	13.61	3.03	1.12034
Non-integrated Simulator	47	12.45	2.83	53	12.19	2.63	0.47398
Non-simulator	122	12.44	3.30	78	13.46	2.73	2.37269
Totals	223	12.90	3.28	177	13.12	2.85	

The nature of the pertinent pre-experimental variables did not require analysis of covariance. The difference of 0.70 between the means of the girls and boys in the integrated simulator treatment was not significant. Also the difference of 0.26 between the means of the girls and boys in the non-integrated simulator treatment was not significant. The difference of 1.02 between the means of the girls and boys in the non-simulator approach was significant at the 2% level of confidence (the obtained t-value exceeded the appropriate table value of 2.326).

Was there a significant difference in attitudinal results between girls and boys (taught by three methods) as measured by the Siebrecht Attitude Scale?

Table 34

FINAL SIEBRECHT ATTITUDE RESULTS BY METHOD AND SEX

	Girls			*Boys*			
Method	*No.*	*Mean*	*S.D.*	*No.*	*Mean*	*S.D.*	*t-value*
Integrated Simulator	54	31.78	3.97	46	29.54	4.29	2.69285
Non-integrated Simulator	47	28.89	4.27	53	28.51	4.35	0.38756
Non-simulator	122	29.74	5.48	78	28.82	4.82	1.24735
Totals	223	30.05	5.01	177	28.98	4.57	

Of the above t-values, the one for the difference between the means of the girls and boys taught by the integrated simulator approach apparently was significant at the 2% level of confidence. Yet this time the nature of the pertinent pre-experimental variables required analysis by covariance.

Table 35

CRITERION (POST-ATTITUDE) AND CONTROL VARIABLES (IQ AND PRE-ATTITUDE) FOR INTEGRATED SIMULATOR STUDENTS BY SEX

	No.	*Post-Attitude*	*IQ*	*Pre-Attitude*
Sex	*k*	*Means*	*Means*	*Means*
Girls	54	31.78	111.93	28.96
Boys	46	29.54	99.96	26.43
Totals	100	30.75	106.42	27.80

Table 36

ANALYSIS OF COVARIANCE FOR POST-ATTITUDE CORRECTING FOR IQ AND PRE-ATTITUDE (BY SEX)

	Residuals		
Source of Variation	*Degrees of Freedom*	*Sum of Squares*	*Mean Square*
Total	97	1468.54425	
Within	96	1448.13972	15.08478
Difference	1	20.40453	20.40453

Covariance resulted in an F ratio of 1.35265 which did not satisfy the table value of 3.94 for 1 and 96 degrees of freedom of the five percent level of confidence. The difference between the means of the girls and boys taught by the integrated simulator method was not significant.

Strengths of Simulator in the Opinion of the Instructors

The four involved instructors who each taught 50 students with the simulator and 50 students without the simulator during the 1963–64 school

year independently listed these strengths of the simulator when asked to do so on August 6, 1964 (the number of instructors who wrote the same comment is indicated parenthetically after each statement):

1. It eliminates fear of driving. (3)

2. Excellent uniform instruction results for all students. (2)

3. It requires fewer explanations and more driving occurs when dual-control car lessons commence. (1)

4. It establishes excellent habits of starting, stopping, hand-over-hand steering, and turn signals before student gets in dual-control car. (3)

5. It provides greater scope by covering areas not covered in dual-control car instruction. (1)

6. Students feel more at ease. (1)

7. There is less chance for teaching errors and fewer problems for instructors. (1)

8. It reinforces skills taught in dual-control car. (1)

Weaknesses of Simulator in the Opinion of the Instructors

On August 6, 1964 the four involved teachers independently listed these simulator weaknesses:

1. Braking, speed, and steering areas should be more realistic. (4)

2. It does not give student a feeling of motion. (2)

3. Not enough is included on emergency situations. (3)

4. "Driving in Reverse" film involves skills which can be best taught in a car. (4)

Additional Comments by Instructors

On August 6, 1964 the four involved instructors independently made these comments:

1. The first four films are the most important and effective. These films are: "The Start of Good Driving," "The Good Turn," "City Driving," and "Highway Driving." (4)

2. If you would give a student six hours of simulation and six hours of on-the-road training, you would have a very strong driver. (1)

3. Practice driving for simulator students should be increased. (1)

4. More coordination of check (rating) rides was needed. (1)

5. Where more than one instructor is used, the simulator does an excellent job of standardizing the instructional program. (4)

IMPLICATIONS

1. Inferences drawn from the findings of this particular study which may be expected to apply in similar circumstances involving high school students are:

a. Immediate standardized learning reinforcement involving instructional films which are coordinated electronically with individual learning stations in a simulator can be used to improve significantly the acquisition of complex mental-motor skills involved in learning to drive an automobile.

b. An integrated approach where simulator instruction is interwoven with dual-control car instruction is superior to both a non-integrated simulator approach and a non-simulator approach in the teaching of driving skills.

c. The modified Neyhart Road Skill Check List for Passenger Car Drivers appears to possess reliability since fourth and final period car error scores were significantly correlated (+0.42 for 400 students).

d. IQ, age, attitude (as measured by the Siebrecht Scale), and knowledge (as measured by the 1962 AAA test) do not correlate significantly with skills involved in learning to drive a car.

e. The new simulator with an integrated instruction method differentiates between good and poor students, particularly when simulator errors are compared with fourth period dual-control car errors.

f. The new simulator with an integrated instruction method produces significantly better results than does the non-simulator approach in the specific areas of driving skill of road position, turn-signals and intersections.

g. The integrated simulator approach appears to produce significantly better results than either the non-integrated simulator or non-simulator methods in such specific areas of knowledge as stopping, night speed, headlights, and passing (as measured by the Harrisburg locally devised knowledge test).

h. The integrated simulator approach appears to result in less dual-control car error variance for girls than would otherwise occur.

i. Girls tend to make fewer dual-control car errors when they are trained with the integrated simulator method than when they are trained with either a non-integrated simulator or a non-simulator course.

j. Girls have a significantly higher probability of passing the State Drivers License Skills Test the first time if they are trained with the integrated simulator approach rather than either a non-integrated simulator or a non-simulator approach.

k. Sex is probably the most and only really important pre-experimental difference in training high school students how to drive a car. On the average girls seem to start driver training at a lower skill level point than do boys.

l. With an integrated teaching approach the new simulator with its immediate learning reinforcement can be used to substitute nine hours of simulated training for three hours of behind-the-wheel instruction in a dual-control car. The practical advantages are readily apparent since one instructor can train twelve students in a simulator rather than two students in a car. The six hours (three of driving and three of observation) saved in car training (with two students per period) can be applied to the training of twelve students at a time in the simulator. Assuming that each driving instructor has four hours per school day and 180 school days for training students to drive a car, then the instructor would have 720 hours per year in which 120 students could be trained two at a time using twelve hours for car instruction in the standard conventional course. With the same 720 hours per year, 192 students could be trained per instructor by using a nine hour simulator course, plus six hours (3 of driving and three of observation) of dual-control car training. The 192×9 or 1728 student simulator hours would require 144 instructor hours (1728 divided by 12) and this would leave 576 (720 minus 144) instructor hours in which to teach six hours of dual-control car training to the 192 students (two students per instructor per car hour). This would mean an increase of 60 percent in the number of students trained per instructor per year, compared with the present conventional standardized program.

m. Accepting l as stated, 384 students could be trained by two instructors with the integrated simulator approach rather than by three instructors with the present conventional standard program. This saving of one instructor would mean an annual saving of approximately $5600. Since the new simulator with its 12 place trailer classroom costs around $26,500.00, the cost of the simulator (including normal preventative maintenance and film repair) would be amortized in less than five years.

n. Accepting l as stated, five instructors teaching four hours a day could train 960 students per school year with the integrated simulator approach. One of these five instructors could spe-

cialize as the simulator instructor while the other four could provide the practice driving in the car (three hours behind-the-wheel and three hours of observation).

2. The following conditions of this particular study may limit the applicability of the above inferences:

a. Only four teachers, one school system, and 400 students were involved.

b. One-half of the students involved in treatment A were taught by the non-integrated simulator method.

3. The recommendations for future research are:

a. A revised replication of this study with the integrated simulator approach for all students trained with the simulator.

b. Reasonably frequent, unannounced, random teacher observation by competent neutral judges to insure teacher adherence to specified teaching strategies and to check on teacher competence and in-service training needs.

c. Determine if a six hour simulator course will do just as well as a nine hour simulator course in substituting for three of the customary six hours of behind-the-wheel training in a dual-control car.

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APPENDICES

APPENDIX A

HARRISBURG CITY SCHOOLS

Driver Education Knowledge Test

Name ..... Date .....

Instructor ..... Period .....

PART I

Write the letter of the best answer in the blank at the left.

..... 1. You must submit an accident report if you are involved in an accident where property damage exceeds (a) $25.00, (b) $50.00, (c) $100.00, (d) $500.00.

..... 2. What does a traffic light flashing yellow indicate to you? (a) caution, (b) danger, (c) stop, (d) construction.

..... 3. At a speed of 50 m.p.h., the total stopping distance is (a) 66 ft., (b) 111 ft., (c) 200 ft., (d) 166 ft.

..... 4. The date on which registration plates expire for passenger cars is (a) January 31, (b) July 31, (c) March 31, (d) October 31.

..... 5. A safe night-time speed is primarily determined by the limits of (a) headlights, (b) weather, (c) posted speeds, (d) traffic.

..... 6. The first thing a driver must do when involved in an accident is (a) call police, (b) stop, (c) assist injured, (d) make report.

..... 7. You are permitted to use the high beam headlights providing there are no cars approaching within (a) 200 ft., (b) 400 ft., (c) 500 ft., (d) 500 yds.

..... 8. To make a left turn from a one-way street, a driver should place his car (a) along the left curb, (b) center lane, (c) right lane, (d) any lane.

..... 9. The distance you must park your car from a fire hydrant is (a) 10 ft., (b) 15 ft., (c) 25 ft., (d) 30 ft.

..... 10. A motor vehicle must be inspected (a) each month, (b) each year, (c) twice a year, (d) every two years.

..... 11. Each inspection period lasts (a) one month, (b) 3 months, (c) 6 months, (d) one year.

..... 12. You may park (a) 10 ft., (b) 15 ft., (c) 25 ft., (d) 30 ft. from a stop sign.

..... 13. A traffic light flashing red means (a) stop, (b) slow, (c) danger, (d) men working.

..... 14. The minimum distance of clear highway necessary for safe passing is (a) 200 ft., (b) 400 ft., (c) 500 ft., (d) 600 ft.

..... 15. When a driver hears the siren of an approaching emergency vehicle, he should (a) slow down, (b) drive to the right, (c) stop, (d) drive to the right and stop.

..... 16. When stopping for a school bus that has stopped on the highway, you must stop (a) 10 ft., (b) 20 ft., (c) 30 ft., (d) 50 ft. from the bus.

..... 17. Driving an automobile in Pennsylvania is a (a) right, (b) duty, (c) privilege, (d) pleasure.

..... 18. You must make an accident report within (a) 12 hrs., (b) 24 hrs., (c) 48 hrs., (d) 90 days.

..... 19. In addition to his operator's license, a driver must have in his possession (a) insurance card, (b) vehicle registration card, (c) credit card, (d) social security card.

..... 20. You may park no closer to a railroad crossing than (a) 10 ft., (b) 20 ft., (c) 30 ft., (d) 50 ft.

..... 21. According to records, the most frequent cause of trouble on the road is (a) out of gas, (b) ignition, (c) tires, (d) carburetor.

..... 22. The type of insurance most important for every car owner is (a) fire, (b) theft, (c) liability, (d) collision.

..... 23. The shape of the traffic sign to indicate a railroad grade crossing is (a) oblong, (b) hexagonal, (c) round, (d) square.

..... 24. As you increase speed, your danger zone (a) widens only, (b) lengthens only, (c) lengthens and widens, (d) shortens.

..... 25. The traffic sign you expect as you enter an expressway is (a) yield, (b) slow, (c) stop, (d) one-way.

Part II

Mark + for true and O for false.

..... 26. As a rule motorists under 20 years of age are safer drivers than those over 40 years of age.

..... 27. When you intend to turn or stop, the law does not require you to give a signal unless there is a vehicle following yours.

..... 28. If you become sleepy while driving, it is best to drink coffee or take anti-doze pills.

..... 29. If one side of the front tires are worn more than the other, the trouble is likely to be wheels out of alignment.

..... 30. A driver who is emotionally immature is most likely to express anger by driving recklessly.

..... 31. A common habit of a discourteous driver is to use the horn frequently.

..... 32. In crossing slippery street car tracks, you should slow down and turn abruptly across the tracks at a wide angle.

..... 33. When you back your car, you have the right of way because you cannot see very well while backing.

..... 34. The amount of alcohol in one cocktail is sufficient to decrease one's keenness of vision.

..... 35. It requires the same distance to slow down from 60 m.p.h. to 50 m.p.h. as it does from 40 m.p.h. to 30 m.p.h.

..... 36. Defective eyesight will affect a driver more adversely in night driving than in day driving.

..... 37. It is not necessary to slow down at an unprotected intersection if you do not see any cross traffic.

..... 38. If a driver seriously injures a pedestrian, legally at fault, the driver does not have to make an accident report.

..... 39. When you drive out of a gas station, street traffic on your left has the right of way.

..... 40. A rear view mirror can be relied upon for a complete view of what's behind your car.

..... 41. You may legally exceed the speed limit when you are driving an injured person to the hospital.

..... 42. More fatal accidents take place on clear, dry days than on stormy days.

..... 43. New non-skid tires have done away with the danger of skidding on wet pavements.

..... 44. If your temperature gauge does not reach normal after a mile of driving, it usually means a defective thermostat.

..... 45. The odometer shows the condition of the car's battery.
..... 46. A full fuel tank prevents water formed by condensation.
..... 47. The function of the carburetor is to vaporize gasoline.
..... 48. Field of vision is your ability to see from side to side.
..... 49. Loss of oil pressure can cause permanent damage to the engine of a car.
..... 50. Good depth perception is most important when passing another car.

APPENDIX B

Modified Neyhart
ROAD TEST CHECK LIST
For Passenger Car Drivers

Name ..... Date .....

School ..... Checked by .....

Instructor ..... Total Deductions .....

	DE-DUCT				
1. *CHECKING THE DRIVER*					
A. Fails to adjust seat properly	1	.....	.....	.....	.....
B. Fails to adjust rear-view mirrors	3	.....	.....	.....	.....
C. Fails to use seat belt	3	.....	.....	.....	.....
2. *STARTING THE VEHICLE*					
A. Selects wrong gear or selector lever position	3	.....	.....	.....	.....
B. Does not release parking brake	1	.....	.....	.....	.....
C. Fails to use brake when moving selector lever	3	.....	.....	.....	.....
3. *BACKING*					
A. Fails to look to the rear while backing	5	.....	.....	.....	.....
B. Backs jerkily	2	.....	.....	.....	.....
C. Oversteers and zigzags when backing	2	.....	.....	.....	.....
4. *STEERING*					
A. Places hands in unstable position on wheel	2	.....	.....	.....	.....
B. Steers abruptly, not smoothly	5	.....	.....	.....	.....
C. Rests arm on window	2	.....	.....	.....	.....
D. Uses one hand habitually	2	.....	.....	.....	.....
5. *POSITION ON ROADWAY*					
A. Fails to drive in proper lane	5	.....	.....	.....	.....
B. Straddles traffic lanes (marked or unmarked)	5	.....	.....	.....	.....
C. Straddles at signal or sign when stopping	5	.....	.....	.....	.....
D. Follows too close to other vehicles	5	.....	.....	.....	.....
E. Drives too close to other vehicles, moving objects, etc.	3	.....	.....	.....	.....

	DE-DUCT				
6. *SPEED CONTROL*					
A. Too fast for conditions	10	.....	.....	.....	.....
B. In excess of marked speed limits	5	.....	.....	.....	.....
C. Too slow for conditions	2	.....	.....	.....	.....
D. Brakes on curves	5	.....	.....	.....	.....
7. *SIGNALING FAILURES*					
A. Turning—fails to signal	2	.....	.....	.....	.....
B. Leaves turn signal on after turning	2	.....	.....	.....	.....
C. Does not signal moving from lane to lane	2	.....	.....	.....	.....
D. Uses horn improperly or fails to use horn	2	.....	.....	.....	.....
8. *SIGNAL VIOLATIONS*					
A. Traffic signal (through on amber)	3	.....	.....	.....	.....
B. Traffic signal (through on red)	10	.....	.....	.....	.....
C. Traffic officer	10	.....	.....	.....	.....
9. *UNCONTROLLED INTERSECTIONS OR THROUGH STREETS*					
A. Fails to slow down with intent to stop if necessary	3	.....	.....	.....	.....
B. Fails to look in all directions	5	.....	.....	.....	.....
C. Fails to respond to hazardous traffic conditions in the making	10	.....	.....	.....	.....
D. Fails to yield right of way	10	.....	.....	.....	.....
10. *STOP STREETS*					
A. Fails to come to full stop	10	.....	.....	.....	.....
B. Fails to stop in a position to see roadway to the right and left	5	.....	.....	.....	.....
C. Hesitates too long for conditions	3	.....	.....	.....	.....
11. *TURNING* (Right)					
A. Approaches from improper lane	3	.....	.....	.....	.....
B. At improper speed (too fast or too slow)	2	.....	.....	.....	.....
C. In improper lane during turn	3	.....	.....	.....	.....
D. Into improper lane after turn	3	.....	.....	.....	.....
E. Strikes curb	3	.....	.....	.....	.....
F. Makes turn unnecessarily wide	1	.....	.....	.....	.....
G. Shies away, then turns right	2	.....	.....	.....	.....
H. Fails to yield right of way	10	.....	.....	.....	.....
12. *TURNING* (Left)					
A. Approaches from improper lane	3	.....	.....	.....	.....
B. At improper speed (too fast or too slow)	2	.....	.....	.....	.....
C. In improper lane during turn	3	.....	.....	.....	.....
D. Into improper lane after turn	3	.....	.....	.....	.....
E. Cuts corner too short	1	.....	.....	.....	.....
F. Cuts corner too wide	1	.....	.....	.....	.....
G. Shies away, then turns left	2	.....	.....	.....	.....
H. Fails to yield right of way	10	.....	.....	.....	.....

13. *STOPPING*

A. Before necessary at signals and signs	1	....
B. Not soon enough (over-running crosswalk or avoidance zone line)	2	....
C. Not at a safe place (too close to other vehicles, etc.)	5	....
D. Stalls engine	5	....

14. *SMOOTHNESS OF OPERATION*

A. Uses brakes roughly or unevenly	5	....
B. Fails to hold accelerator steady	5	....

15. *PASSING OTHER VEHICLES GOING IN SAME DIRECTION*

A. Fails to make sure road ahead and behind is clear	10	....
B. Passes at intersection	10	....
C. Cuts back into line too soon after passing	5	....
D. Passes by weaving through traffic	5	....

16. *NERVOUS AND HESITANT*

Not at all	0
Occasionally	5
Often	10
All the time	15

OVERCONFIDENT

Not at all	0
Part of time	5
Cocky	10

FAILS TO USE REAR-VIEW MIRRORS

Not at all	0
Part of time	3
Over entire route	5

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APPENDIX C

AN ESTIMATE OF THE VALIDITY AND RELIABILITY OF THE MODIFIED NEYHART ROAD TEST CHECK LIST FOR PASSENGER CAR DRIVERS

Problem: While planning an experiment to determine the effectiveness of a new driving simulator, the question arose as to whether a modified Neyhart Road Test Check List for Passenger Car Drivers[1] could serve as one of the evaluative instruments.

Objectives: 1. To obtain an estimate of the reliability of the Neyhart Road Test Check List for Passenger Car Drivers.

2. To obtain an estimate of the inter-judge reliability for the two judges involved.

3. To obtain an estimate of the criterion reliability.

4. To obtain an estimate of the validity of the Neyhart Road Test Check List for Passenger Car Drivers.

Procedures: The scale was used in April of 1963 to rate nine high school juniors (who were completing driver training) and four adult volunteers. Each judge independently and simultaneously rated each subject while the subject drove over a prescribed course involving city driving. The reliability of the Neyhart scale was estimated by the intraclass correlation method described by Ebel[2]

[1] See Appendix B.

[2] R. L. Ebel, "Estimation of the Reliability of Ratings," *Psychometrika*, 1951, Vol. 16, pp. 407–424.

and recommended by Guilford[3] for use with ratings. An estimate of interjudge reliability was computed by the Kendall rank correlation coefficient r'.

Within three days of the ratings of subjects on the Neyhart scale, all subjects were again rated by two experienced State policemen who have been administering the driver's license in Pennsylvania for over three years. Each State Policeman independently and simultaneously observed each subject's driving skill on the standard official examination course approved by the State of Pennsylvania for the Harrisburg area. The subjects were then rated immediately and independently by each examining officer on a graphic scale with the following five categories:

Superior—Does all things well.

Excellent—Does most things well.

Satisfactory—Is acceptable for a license.

Satisfactory in many areas but made one or more major mistakes and not qualified at this time.

Clearly unacceptable at this time.

After all thirteen subjects had been rated on the above five category graphic scale, each officer also independently ranked each person from 1 to 13. By using these ranks an estimate of criterion reliability was possible through the Kendall rank correlation coefficient r.

An estimate of the validity of the Neyhart scale was facilitated by computing a Kendall coefficient of concordance W[5] between all four rankings of the subjects in the sample. This correlation was corrected for attenuation by dividing the obtained coefficient (between rankings of the judges and rankings of the State Policeman) by the square root of the coefficient of criterion reliability.[6]

Results: First, the reliability of ratings on the Neyhart scale was computed by intraclass correlation procedures as outlined in Guilford.[7] An estimate of the coefficient of reliability of the Neyhart scale of .71 was obtained for a single rater. An estimate of the coefficient of reliability of the Neyhart scale of .83 was obtained for two raters combined or for the averages of their ratings. The computation of the foregoing coefficients is explained briefly in the next two tables and in the two paragraphs subsequent to these tables.

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[3] J. P. Guilford, *Psychometric Methods*, New York: McGraw Hill Book Co., Inc., 1954, pp. 395–397.

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[4] S. Siegel, *Nonparametric Statistics for the Behavioral Sciences*, New York: McGraw Hill Book Co., Inc., 1956, pp. 213–223.

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[5] *Ibid.*, pp. 229–238.

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[6] *Op. Cit.*, Guilford, pp. 401–402.

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[7] *Ibid.*, pp. 395–397.

Table 1

RATINGS* OF THIRTEEN PERSONS MADE BY TWO RATERS USING THE NEYHART ROAD TEST CHECK LIST FOR PASSENGER CAR

Person	Rater A	Rater B	ΣX_p	$(\Sigma X_p)^2$
1	71.5	80.5	152	23 104.00
2	69.5	57.0	126.5	16 002.25
3	90.0	88.0	178.0	31 684.00
4	75.5	86.5	162.0	26 244.00
5	64.5	82.5	147.0	21 609.00
6	37.5	59.0	96.5	9 312.25
7	70.5	80.0	150.5	22 650.25
8	70.5	87.0	157.5	24 806.25
9	34.5	71.5	106.0	11 236.00
10	88.0	94.0	182.0	33 124.00
11	85.5	87.5	173.0	29 929.00
12	96.0	98.0	194.0	37 636.00
13	88.5	86.0	174.5	30 450.25
ΣXr	942.0	1 057.5	1 999.5 = ΣX	317 787.25
$(\Sigma Xr)^2$	887 364	1 118 306.25	2 005 670.25 = $\Sigma(\Sigma Xr)^2$	
ΣX^2	160 358.75			$\frac{(\Sigma X)^2}{kN}$ = 153 769.24

* Ratings were transposed to positive scores by subtracting the number of deductions for each person from 100.

Table 2

SUMMARY OF VARIANCES FOR RATINGS GIVEN IN TABLE 1

Source	Sum of Squares	Degrees of Freedom	Variance
From Persons	5 124.39	12	427.03
From Raters	603.09	1	—
From Error	862.03	12	71.84
Total	6 589.51	25	—

An estimate of the coefficient of reliability of the Neyhart scale for a single rater was then computed as follows:

$$r_{11} = \frac{V_p - V_e}{V_p + (k-1)V_e} = .71$$

An estimate of the coefficient of reliability of the Neyhart scale for the two raters combined or for the average of their ratings was then computed as follows:

$$r_{kk} = \frac{V_p - V_e}{V_p} = .83$$

Secondly, an estimate of the interjudge reliability on the Neyhart scale was computed by the Kendall rank correlation coefficient: r. A correlation of .67 resulted as an indication of the degree of relation betweeen the ratings of two judges of thirteen subjects on the Neyhart scale.

After the scores of the judges had been changed to ranks the following table resulted:

Table 3

RANKINGS* OF TWO JUDGES USING THE NEYHART SCALE WITH THIRTEEN SUBJECTS

Subjects	1	*c*	*m*	*j*	*k*	*d*	*a*	*h*	*g*	*b*	*e*	*f*	*i*
Judge A	1	2	3	4	5	6	7	8.5	8.5	10	11	12	13
Judge B	1	3	7	2	4	6	9	5	10	13	8	12	11

* Rankings arranged so Judge A's ranks appear in natural order.

The degree of correlation between the above two sets of ranks were then computed as follows:**

$$r = \frac{S}{\frac{1}{2}N(N-1)} = \frac{52}{78} = .67$$

The correlation coefficient of .67 for the inter-judge reliability on the Neyhart scale was then tested for significance by using the following formula:[8]

$$z = \frac{r}{\sqrt{\frac{2(2N+5)}{9N(N-1)}}} = 3.19$$

The above z value has probability of occurrence under the null hypothesis of p = .0012. Thus the null hypothesis was rejected and it was concluded that the ratings of the two judges were closely related for the population from which the sample was drawn.

Third, an estimate of criterion reliability was obtained for the rankings of the state police licensing examiners. Here a Kendall rank correlation coefficient of .69 was obtained between the rankings of the two officers of the thirteen subjects.

After the rankings had been arranged so the ranks of Officer O appeared in natural order the following table resulted:

Table 4

RANKINGS OF TWO OFFICERS OF THIRTEEN SUBJECTS' DRIVING SKILL OVER A PRESCRIBED COURSE

Subjects	*l*	*j*	*c*	*f*	*m*	*a*	*k*	*i*	*b*	*g*	*h*	*e*	*d*
Officer O*	1	2	3	4	5	6	7	8	9	10	11	12	13
Officer X*	1	4	5	2	3	8	9	6	11	10	7	13	12

* (The codes "O" and "X" were assigned privately by the officers themselves.)

Then the coefficient of criterion reliability was computed by:

$$r = \frac{S}{\frac{1}{2}N(N-1)} = .69$$

A z value for the above coefficient was then computed to be 3.29. This z value has a probability of occurrence under the null hypothesis of p = .0005. Thus, the null hypothesis was rejected and it was concluded that the ratings of the two officers correlate highly for the population from which this sample was drawn.

Fourth, an estimate of the correlation of all four rankings of the thirteen subjects was computed. Here the Kendall coefficient of concordance W was used.[9]

Table 5

RANKS ASSIGNED TO THIRTEEN SUBJECTS BY TWO JUDGES USING THE NEYHART SCALE AND TWO OFFICERS USING A FIVE POINT GRAPHIC SCALE

Subjects	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*
Judge A	7	10	2	6	11	12	8.5	8.5	13	4	5	1	3
Judge B	9	13	3	6	8	12	10	5	11	2	4	1	7
Officer O	6	9	3	13	12	4	10	11	8	2	7	1	5
Officer X	8	11	5	12	13	2	10	7	6	4	9	1	3
R_j	30	43	13	37	44	30	38.5	31.5	38	12	25	4	18

** In this case the formula for ties does not appreciably improve this correlation.

[8] *Op. Cit.*, Siegel, pp. 221–222 and pp. 247.

[9] *Op. Cit.*, Siegel, pp. 229–238.

The Kendall coefficient of concordance was then computed as indicated:

$$W = \frac{s}{\frac{1}{12}k^2(N^3 - N)} = \frac{1958.5}{\frac{1}{12}(2197 - 13)} = .67256$$

The above coefficient was then tested for significance by obtaining a chi square value by:

$$k(N - 1)W = 4(12)(.67256) = 32.28$$

For twelve degrees of freedom this chi square value of 32.28 exceeds the table value of chi square at the 1% level of confidence. Thus, it is indicated that the ratings of the judges and of the State Policemen are related to each other for the population from which the sample was drawn.

Finally, the validity of the Neyhart scale was estimated by the formula which corrects only the criterion for attenuation.[10]

This formula is:

$$r_{xu} = \frac{r_{xy}}{\sqrt{r_{yy}}} = \frac{.67}{\sqrt{.69}} = .81$$

[10] *Op. Cit.*, Guilford, p. 401.

Implications of Results: The modified Neyhart Scale appears to have satisfactory reliability and validity for the population from which the sample for this experiment was drawn. The estimate of the coefficient of reliability of the Neyhart scale for a single rater was .71 and for the averages of the two raters the estimated reliability coefficient was .83. The estimated coefficient of validity for the Neyhart scale was .81 when correction was made for attenuation in the criterion.

The interjudge coefficient of reliability was .67 for the Neyhart scale. A criterion coefficient of reliability of .69 was obtained for the rankings of the two State Policemen who administer the State license examinations for the Harrisburg area. These coefficients satisfied appropriate tests of significance at better than the 1% level of confidence.

It is indicated that the modified Neyhart Road Check List for Passenger Car Drivers is a satisfactory driver road skill rating scale.